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WEATHER BASED WHEAT YIELD FORECASTING IN EASTERN ZONE OF HARYANA

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ABSTRACT

Forecasting of crop production is needed by the national and state governments for various policy decisions relating to storage, distribution, pricing, marketing, import-export etc. In this paper, a methodology for the estimation of wheat yield, ahead of harvest time is developed, specifically for wheat growing districts of eastern zone of Haryana (India). The eastern zone comprises Rohtak, Karnal, Jind, Sonipat, Panipat and Kaithal districts. Zonal yield models, using time trend and weather predictors are generated using principal component analyses. The estimated yield(s) from the selected models indicated good agreement with State Department of Agriculture (DOA) of wheat yields, by showing 2-12 percent average absolute deviations.

KEYWORDS: *Eigen Values, Principal Component Scores, Percent Deviation and Weather Parameters*

Article History

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INTRODUCTION

India has a well-established system for collecting agricultural statistics. In fact, as early as 1884, wheat production estimation was done for the first time in India. The primary responsibility for collection of data regarding the area under different crops and production of crops is that of the State Governments. The Ministry of Agriculture of the Central Government has the responsibility of compilation of area and production of major crops at national level. Area assessment is based on complete enumeration by revenue agencies. Yield estimates obtained through analysis of scientifically designed crop-cutting experiments (Sukhatme and Panse, 1951) are routinely issued by the Directorate of Economics and Statistics. However, the final estimates are given a few months after the actual harvest of the crop. Thus, one of the limitations of the conventional method used is timeliness and quality of the statistics. This suggests that improvement of these statistics for planning and management purposes is urgently needed. Thus, our study aims at developing such an improved methodology for crop yield forecasting.

Various organizations in India and abroad are engaged in developing methodology for pre-harvest forecasting of crop yield, using different approaches. The most commonly used models are based on empirical statistical models. The main factors affecting the crop yield are agricultural input and weather parameters. Use of these factors forms a broad category of models for forecasting crop yield. Hoogenboom (2000), Kandiannan *et al*. (2002), Bazgeer *et al*. (2007), Esfandiary *et al*. (2009), Lobell and Burke (2010), Basso *et al*. (2012) etc. have used a series of weather predictors for crop

yield forecasting. Goyal and Verma (2015) have used agromet/spectral indices in context of pre-harvest yield forecasting of different crops in Haryana.

Crop Status and Study Region

Wheat is one of the most important cereal crops in India, as it forms a major constituent of the staple diet of a large part of the population. India occupies second place in terms of acreage and production among wheat growing countries of the world (Source:www.mapsofindia.com/indiaagriculture/). Haryana occupies third place for wheat production (Source: www.agricoop.nic.in/statistics) among the various states in India. Rohtak, Karnal, Jind, Sonipat, Panipat and Kaithal districts falling under the eastern zone of Haryana have been considered for the model building.

The Department of Agriculture (DOA)'s wheat yield of the districts under consideration from 1980-81 to 2013-14 were used for time-trend analysis, and then computing the trend based yield i.e. $T_r = a + bt$, where T_r = Trend yield, a = Intercept, b = Slope and t = Year. Weather data starting from 1^{st} fortnight of November to 1 month before harvest has been utilized for the model building (crop growth period: 1^{st} November to 15^{th} April). The average weather value calculated over 1st to 15th November gives 1st fortnight weather parameter(s), average value calculated over 16^{th} to 30th November provides 2nd fortnight weather parameter(s) and proceeding in the next year, the average weather value calculated over 16th to 31st March and 1st to 15th April gives the 10th and 11th fortnight weather. The fortnightly parameter(s) form 1^{st} November to 1 month before harvest during the crop growth period viz., Tmx_1, Tmx_2, ...,Tmx_9, Tmn_1, Tmn_2,...,Tmn_9 and Arf_1, Arf_2, ..., Arf_9 have been used to develop the zonal yield models.

RESULTS AND DISCUSSIONS

Principal component method was used for the extraction of factors, which consists of finding the eigen values and eigen vectors. Principal components P_i (i=1, 2…) were obtained as P = kX , where P and X are the column vectors of transformed and the original variables respectively, and k is the matrix with rows as the characteristic vectors of the correlation matrix R. The variance of P_i is the i^{th} characteristic root λ_i of the correlation matrix R; λ_s were obtained by solving the equation $|R- \lambda I| =0$.

Zonal wheat yield models based on weather data of 1980-81 to 2009-10 were developed within the framework of principal component analyses. The validity of the models was checked for the post sample period 2010-11 to 2013-14 for eastern zone of Haryana. Under PC analysis, first ten PCs (Table 1) of correlation matrix of weather variables explained about 82% of the variability, and thus the remaining components accounted for a smaller amount of total variation, hence those components were not considered to be of much practical significance.

Table 1: Eigen Values and Variance (%) Explained by Different Principal Components

Components	1	2	3	4	5	6	7	8	9	10
Eigen value (% variance explained)	5.10 (18.90)	3.74 (13.85)	3.02 (11.19)	2.81 (10.39)	2.07 (07.67)	1.89 (07.02)	1.48 (05.48)	1.12 (04.15)	1.06 (03.92)	0.90 (03.32)

Zonal wheat yield models were fitted by taking weather (PC) scores and trend yield as regressors and DOA crop yield as regress and. The best subsets of predictors were selected using the stepwise regression (Draper and Smith, 2003) method, in which all variables were first included in the model and eliminated one at a time, with decisions at any

particular step, conditioned by the result of the previous step. The selected zonal yield model along with R^2 and standard error is given below:

$$Yield_{est} = 0.31 + 0.99 *Tr - 0.73 * PC_1 + 0.81 * PC_2 - 0.51* PC_7$$

$R^2 = 0.911$, adj.$R^2 = 0.909$ & SE= 2.14

Where $Yield_{est}$ - Model predicted yield

T_r - Linear time trend based yield

PC_i - i^{th} principal component score (i = 1,2,…,10)

R^2 - Coefficient of determination

SE - Standard error of yield estimate

The model based yield(s) showing a good agreement with the real time data along with percent relative deviations are given in Table 2.

Table 2: District-Specific Wheat Yield Forecast along with Percent Deviations from Real-Time Yield(s) Using the Fitted Models

Districts/ Years	Rohtak			Karnal			Jind		
	Obs. Yield (q/ha)	Fitted Yield (q/ha)	RD(%)	Obs. Yield (q/ha)	Fitted Yield (q/ha)	RD(%)	Obs. Yield (q/ha)	Fitted Yield (q/ha)	RD(%)
2010-11	45.52	43.28	4.92	44.47	49.36	-10.99	45.45	48.26	-6.19
2011-12	50.2	43.08	14.18	56.7	49.24	13.15	52.35	48.23	7.88
2012-13	37.38	44.38	-18.72	46.7	50.62	-8.39	42.7	49.69	-16.36
2013-14	39.24	44.52	-13.44	49.12	50.84	-3.51	45.49	49.99	-9.89
Av. abs. Dev	12.81			9.01			10.08		

Table 3

Districts/Years	Sonipat			Panipat			Kaithal		
	Obs. Yield (q/ha)	Fitted Yield (q/ha)	RD(%)	Obs. Yield (q/ha)	Fitted Yield (q/ha)	RD(%)	Obs. Yield (q/ha)	Fitted Yield (q/ha)	RD(%)
2010-11	46.43	47.99	-3.35	40.88	43.21	-5.70	47.2	47.36	-0.34
2011-12	55.21	47.94	13.17	39.17	43.48	-11.00	54.51	47.06	13.66
2012-13	45.2	49.40	-9.29	42.47	45.24	-6.53	46.84	48.26	-3.04
2013-14	46.5	49.69	-6.86	42.83	45.85	-7.06	48.15	48.31	-0.33
Av. abs. Dev	8.17			7.57			4.34		

Percent Relative Deviation (RD%) = 100 × [(observed (obs.) yield – fitted yield) / observed yield]

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